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(54) **Fuel injection pumping apparatus**

(57) A rotary distributor type pumping apparatus has a cam ring having lobes 15 engaged in use by a follower 14 to impart inward movement to a pump plunger. The cam lobe has a trailing flank which includes a first sloping portion 48 an intermediate portion 47 during which the plunger remains substantially stationary and a second sloping portion which is shaped to correspond substantially with the natural flight path 51 of the follower. Just before the cam follower contacts the base circle 50 the second sloping portion departs from the natural flight path so that the follower contacts the cam ring base circle as smoothly as possible.

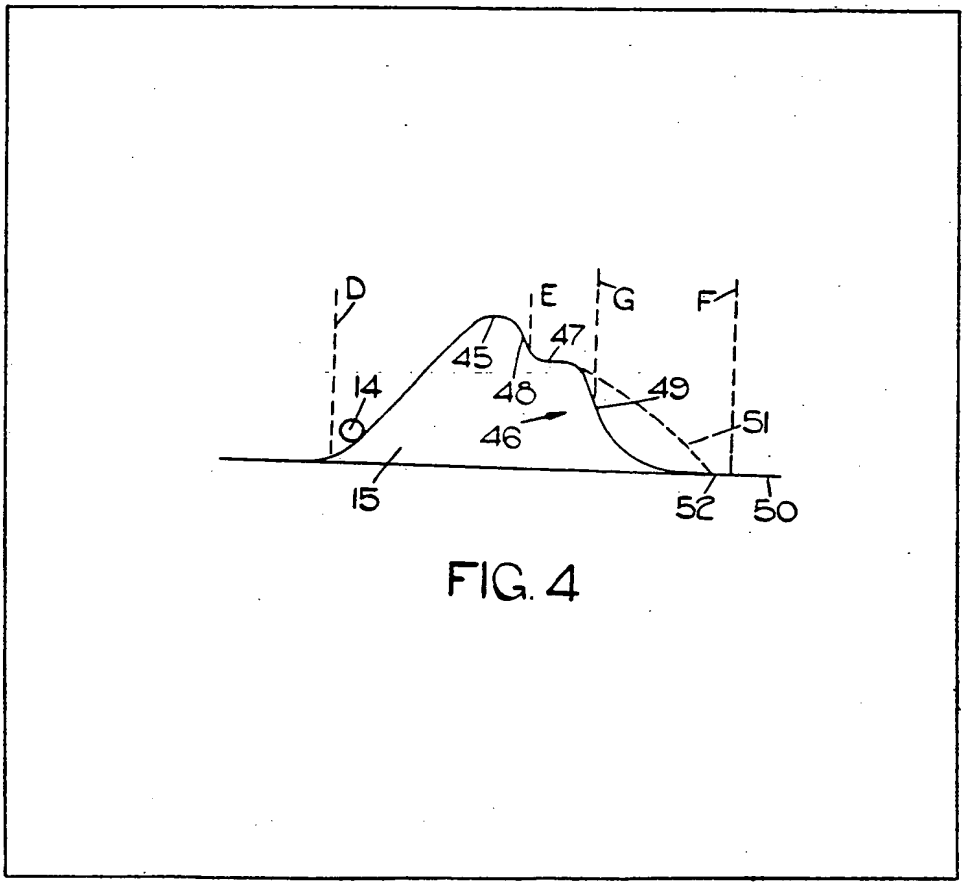

FIG. 4

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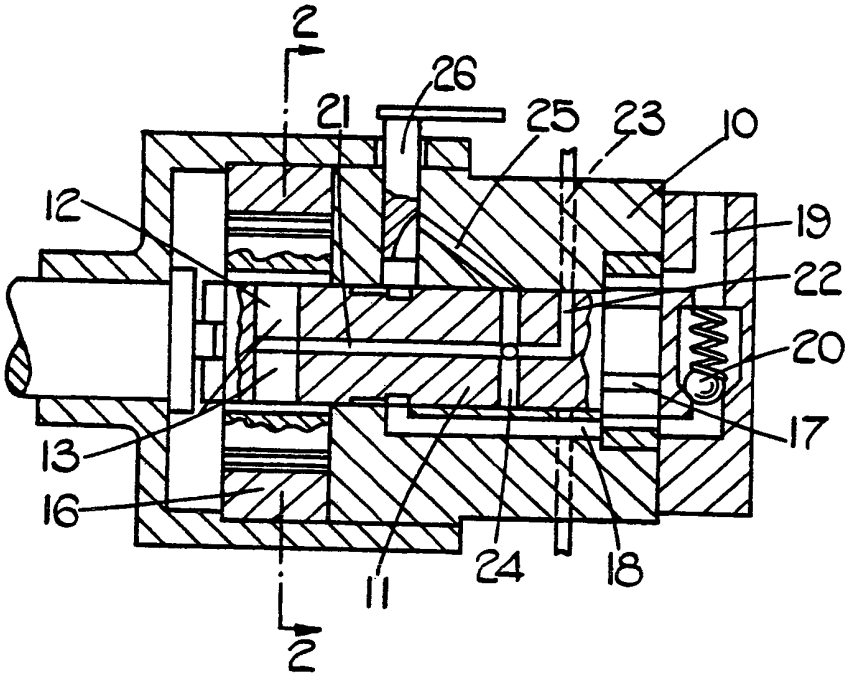

FIG.1.

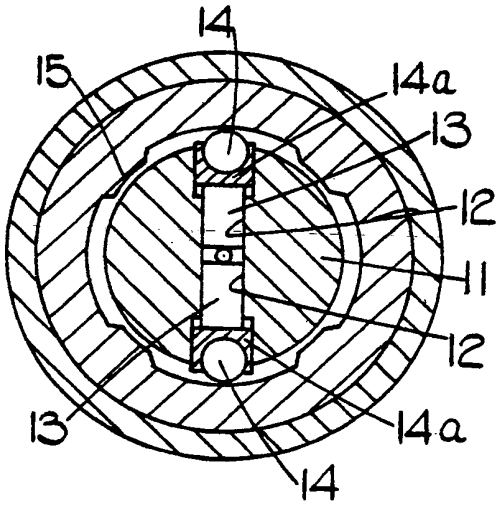

FIG.2.

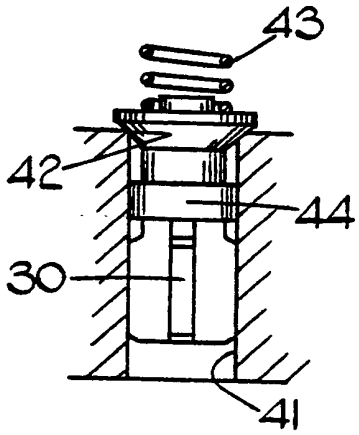

FIG.3.

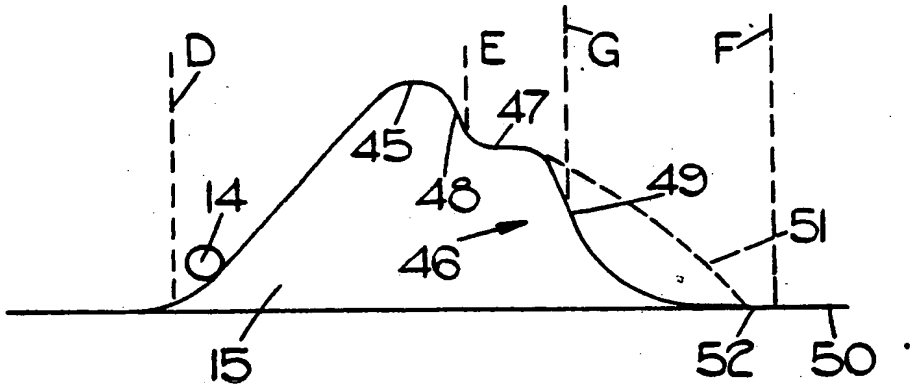

FIG. 4

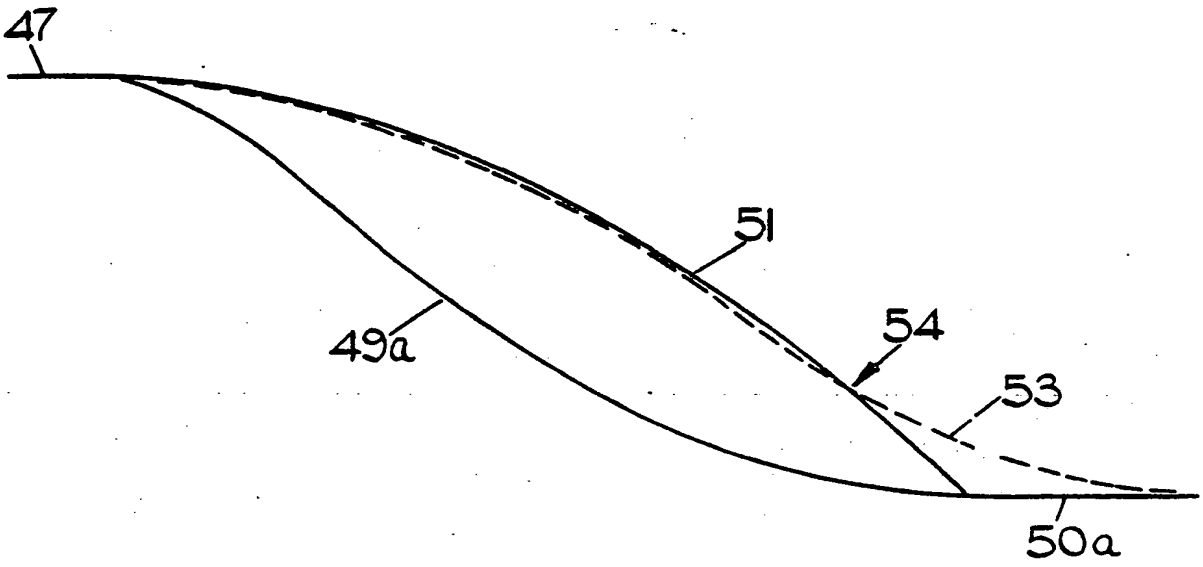

FIG. 5.

SPECIFICATION

Fuel injection pumping apparatus

This invention relates to fuel injection pumping apparatus of the kind comprising a rotary distributor member which in use is driven in timed relationship with the associated engine, a plunger located within a radial bore formed in the distributor member, a delivery passage registering in turn and during successive pumping strokes of the plunger with a plurality of outlet ports formed in a surrounding body, a cam ring surrounding the distributor member, a plurality of cam lobes formed on the internal periphery of the cam ring, a cam follower operable by the cam lobes in turn, said cam follower imparting inward movement to the plunger so that the latter partakes of a pumping stroke, each cam lobe having a leading flank which engages the follower to cause inward movement of the pumping plunger, and a trailing flank having an intermediate portion during which the outward movement of the follower is prevented, the intermediate portion being preceded by a first sloping portion which extends from the crest of the cam lobe to the intermediate portion, and the intermediate portion being followed by a second sloping portion which extends from the intermediate portion to the base circle of the cam ring, and means for supplying fuel to said bore.

Such apparatus is well known and it is the practice to allow the delivery passage to remain in communication with an outlet port until the cam follower and the plunger have been brought to rest by the intermediate portion of the trailing flank of the cam lobe. This causes a rapid reduction in the pressure of fuel in the delivery passage and the outlet to which it is connected by allowing a predetermined volume of fuel to flow from the outlet towards the bore. The pressure of fuel acting on the plunger acts to maintain the follower in contact with the first sloping portion of the trailing flank. However, during the movement of the follower along the intermediate portion of the trailing flank the aforesaid communication of the delivery passage and the outlet port is broken and as a result when the cam follower moves from the intermediate portion of the trailing flank the pressure acting on the plunger is very much reduced. In fact the plunger may until fuel is supplied to the bore, be unable to move outwardly because of the creation of an hydraulic lock. As a result the cam follower being subject to centrifugal force separates from the plunger and moves outwardly towards the cam ring. In known forms of the apparatus the second sloping portion of the trailing flank is so steep that the follower may separate from the cam lobe and follow a natural flight path until it contacts the cam ring at a position on the base circle intermediate adjacent lobes. When the cam follower contacts the cam ring appreciable noise may be generated which can make a significant contribution to the general mechanical noise generated by the apparatus.

The object of the invention is to provide an apparatus of the kind specified in a simple and convenient form and in which the noise generated by the apparatus is minimised.

According to the invention in an apparatus of the kind specified, the initial part of the aforesaid second sloping portion of the trailing flank of each cam lobe is shaped so that it substantially corresponds to the natural flight path of the cam follower, the final part of said second sloping portion being shaped so that the cam follower is taken out of its natural flight path whereby the cam follower remains in contact with the cam lobe until the cam follower reaches the base circle of the cam ring, the point at which the cam follower reaches the base circle occurring before the supply of fuel to the bore is prevented.

An example of an apparatus in accordance with the invention will now be described with reference to the accompanying drawings in which:—

Figure 1 is a sectional side elevation of the apparatus,

Figure 2 is a section on the line 2—2 of Figure 1,

Figure 3 is a side elevation of a part which can be incorporated in the apparatus of Figures 1 and 2, and

Figure 4 is a developed view to an enlarged scale of the profile of a cam lobe forming part of the apparatus seen in Figures 1 and 2.

Figure 5 is a view to an enlarged scale showing the path of movement of a part of the apparatus.

Referring to the drawings, the liquid fuel pumping apparatus illustrated is for supplying fuel to a four cylinder compression ignition engine and there is provided a body part 10 in which is mounted a rotary cylindrical distributor 11 which is adapted to be driven in timed relationship with the engine with which the apparatus is associated. At one end of the distributor is formed a transversely extending bore 12 in opposite ends of which are slidably accommodated a pair of pumping plungers 13. The plungers are adapted to be moved inwardly as the distributor rotates by the interaction of cam followers in the form of rollers 14, with two pairs of diametrically disposed cam lobes 15 formed on the internal peripheral surface of an annular cam ring 16 mounted in the body and surrounding the distributor member. The rollers are mounted in shoes 14A which are accommodated in slots formed in the distributor member.

At the other end of the distributor member is mounted the rotary part of a van type feed pump 17 having an outlet 18 formed within the body part and an inlet 19 for communication with a source of fuel. The inlet and outlet of the feed pump are interconnected by way of a relief valve 20 which acts to control the output pressure of the feed pump.

Formed in the distributor member is a longitudinal passage 21 which at one end is in communication with the transversely extending bore 12. At another point the longitudinal passage is in communication with a radially disposed

delivery passage 22 also formed in the distributor member, and which is arranged to register in turn as the distributor member rotates, with four equiangularly spaced delivery ports 23 formed in the body part and in communication respectively with four outlets. In use, the outlets are connected by way of pipe lines respectively to the injection nozzles (not shown) of the associated engine. At another point the longitudinal passage communicates with four equiangularly spaced and radially disposed inlet passages 24, which are arranged to register in turn and as the distributor rotates, with an inlet port 25 formed in the body part. The inlet port is in communication with the outlet 18 of the feed pump by way of passages within the body part. A throttle valve 26 is provided between the outlet of the feed pump and the inlet port, and the setting of the throttle valve is controlled by a speed responsive governor (not shown), the governor including an operator adjustable member whereby the operator can select up to the maximum speed allowed by the governor, the desired speed of the associated engine. The communication between the delivery passage 22 and a delivery port 23 is arranged to occur when the plungers are moved inwardly by the cam lobes 15 and the registration of an inlet passage 24 with the inlet port 25 is arranged to occur during the interval between successive injection strokes.

Each outlet 23 is provided with a so called unloading delivery valve of the kind as shown in Figure 3. Each valve comprises a body which at its lower end is provided with flutes 30 for guiding the axial movement of the body within a bore 41 which forms part of the outlet. The upper portion of the body is of truncated conical form and defines a closure element for co-operation with a seating 42 defined about the bore. The valve body is loaded by a coiled compression spring 43 so that the closure element is urged into contact with the seating. Moreover, intermediate the closure element and the fluted portion of the body is a plane cylindrical collar 44.

In use, fuel flowing through the bore 41 from the delivery passage, moves the body against the action of the spring until fuel can flow past the collar to the outlet. When the flow of fuel ceases the spring urges the body in the reverse direction and in so doing a predetermined quantity of fuel is returned to the transversely disposed bore 12 before the other portion of the body contacts the seating 42.

The profile of the came lobe 15 is shown more clearly in Figure 4. The delivery passage 22 opens to an outlet port at point D and as the roller 14 moves inwardly owing to the action of the leading flank of the lobe the associated plunger is also moved inwardly and fuel is displaced through the delivery passage. When the roller reaches the crest of the cam lobe inward movement of the plunger ceases. The crest of the cam lobe is indicated at 45 and the trailing flank of the cam lobe is indicated at 46. The trailing flank includes an intermediate portion 47, a first sloping portion 48 which connects the crest 45 with the intermediate portion 47, and a second sloping portion 49 which connects the intermediate portion 47 with the base circle indicated at 50, of the cam ring. When the roller 14 passes over the crest 45 the plunger is allowed to move outwardly under the action of the high pressure existing in the outlet and during this time the delivery valve allows a predetermined quantity of fuel to flow back towards the bore 12. This flow of fuel causes a rapid reduction in pressure in the outlet thereby enabling the valve in the associated fuel injection nozzle to close quickly. The delivery valve closes at approximately the position E and the rollers move on to the intermediate portions 47 of the respective cam lobes. During their movement along the intermediate portion they are held against outward movement and this allows the fuel pressure within the passages within the distributor member to stabilise. When the roller moves from the intermediate portion to the second sloping portion 49, a further slight outward movement of the plungers will occur to relieve the pressure within the passages and if the plunger were biased by a spring in the outward direction, and the pump were operated at a low speed, the roller would follow the second sloping portion 49 of the cam lobe. It will be noted that point G is indicated, this being the position at which the delivery passage 22 moves out of register with the outlet 23. This does not influence the movement of the plunger in any way because the delivery valve is already closed. Following closure of the delivery passage 22 one of the inlet passages 24 opens to the inlet port 25 and fuel can then flow to the bore 21. This causes outward movement of the plunger by an amount determined by the setting of the throttle valve 26. Point F is indicated as being the position at which the inlet passage 24 moves out of register with the inlet port 25.

It was stated above that the roller would follow the second sloping portion 49 of the trailing flank of the cam lobe if the associated plunger were biased by a spring. The plunger is not baised in this manner and moreover, its outward movement when an inlet passage has moved into register with an inlet port, is controlled by the rate of fuel flow. The roller and shoe are subject to centrifugal force and what in fact happens is that the roller and shoe separate from the plunger and move along a natural flight path indicated at 51. Appreciable noise can be generated when the roller encounters the base circle 50 of the cam ring and the noise generated will contribute to the general mechanical noise generated by the apparatus.

Figure 5 illustrates the locus of the axis of the roller during its movement over the second sloping portion 49 of the cam lobe and the base circle 50. The natural flight path is shown at 51 and at 49*a* is shown the locus of the roller assuming it were held in contact with the cam lobe. The dotted line 53 shows the locus of the axis of the roller when the cam profile is modified in accordance with the

invention. It will be seen that the cam profile is such that the natural flight path is followed for the major portion of the cam lobe profile but at point 54 the cam lobe is shaped so that the roller is taken out of its natural flight path so that it moves smoothly towards the path 50*a* which corresponds to the base circle of the cam. The point 52 in Figure 4 is the point where the roller would engage the base circle of the cam. The point on the base circle 50 where the roller does smoothly engage with the bore circle is arranged to occur before the point F so that the plunger can move outwardly to its correct position as determined by the setting of the throttle member.

CLAIMS

1. A fuel injection pumping apparatus of the kind comprising a rotary distributor member which in use is driven in timed relationship with the associated engine, a plunger located within a radial bore formed in the distributor member, a delivery passage communicating with said bore, said delivery passage registering in turn and during successive pumping strokes of the plunger with a plurality of outlet ports formed in a surrounding body, a cam ring surrounding the distributor member, a plurality of cam lobes formed on the internal periphery of the cam ring, a cam follower operable by the cam lobes in turn, said cam follower imparting inward movement to the plunger so that the latter partakes of a pumping stroke, each cam lobe having a leading flank which engages the follower to cause inward movement of the pumping plunger, and a trailing flank having an intermediate portion during which the outward movement of the follower is prevented, the intermediate portion being preceded by a first sloping portion which extends from the crest of the cam lobe to the intermediate portion, and the intermediate portion being followed by a second sloping portion which extends from the intermediate portion to the base circle of the cam ring, and means for supplying fuel to said bore, characterized in that the initial part of the aforesaid second sloping portion of the trailing flank of each cam lobe is shaped so that it substantially corresponds to the natural flight path of the cam follower, the final part of said second sloping portion being shaped so that the cam follower is taken out of its natural flight path whereby the cam follower remains in contact with the cam lobe until the cam follower reaches the base circle of the cam ring, the point at which the cam follower reaches the base circle occurring before the supply of fuel to the bore is prevented.

2. A fuel injection pumping apparatus comprising the combination and arrangement of parts substantially as hereinbefore described with reference to the accompanying drawings.

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